WPS2132

POLICY RESEARCH WORKING PAPER 2132

A Regime-Switching Approach to Studying Speculative Attacks

A Focus on European Monetary System Crises

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A regime-switching framework is used to study speculative attacks against European Monetary System currencies during 1979-93

The World Bank
Development Research Group
Finance
June 1999

Summary findings

Peria uses a regime-switching framework to study speculative attacks against European Monetary System (EMS) currencies during 1979–93.

She identifies speculative attacks by modeling exchange rates, reserves, and interest rates as time series subject to discrete regime shifts. She assumes two states: "tranquil" and "speculative."

She models the probabilities of switching between states as a function of fundamentals and expectations.

She concludes that:

- The switching models with time-varying transition probabilities capture most of the conventional episodes of speculative attacks.
- Speculative attacks do not always coincide with currency realignments.
- Both economic fundamentals and expectations determine the likelihood of switching from a period of tranquility to a speculative attack. The budget deficit appears to be an especially important factor driving the probability of switching to a speculative regime.

Given the importance of anticipating and, wherever possible, avoiding crises, it might be useful to conduct forecasting exercises to determine whether the switching framework proposed here can be used to forecast crises in countries outside the sample.

Because currency crises tend to occur simultaneously in two or more countries, it also might be useful to adapt the regime-switching framework to explore the role of contagion in explaining crises.

This paper — a product of Finance, Development Research Group — is part of a larger effort in the group to understand currency crises. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Agnes Yaptenco, room MC3-446, telephone 202-473-8526, fax 202-522-1155, Internet address ayaptenco@worldbank.org. Policy Research Working Papers are also posted on the Web at http://www.worldbank.org/html/dec/Publications/Workpapers/home.html. The author may be contacted at mmartinezperia@worldbank.org. June 1999. (52 pages)

A Regime Switching Approach to Studying Speculative Attacks:

A Focus on European Monetary System Crises

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JEL Classification Codes: F30, F33, C32
Keywords: Exchange rates, speculative attacks, EMS, Markov regime-switching models

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* I am especially indebted to Barry Eichengreen, Richard Lyons, Maurice Obstfeld, and James Powell for their advice and encouragement. I greatly benefited from discussions with David Bowman, Jon Faust, Michael Gibson, Dale Henderson, Chang-Tai Hsieh, Steve Kamin, Andy Levin, Gian Maria Milesi-Ferreti, John Rogers, Tom Rothenberg, Paul Ruud, and Sergio Schmukler. Furthermore, fruitful suggestions were provided by seminar participants at related presentations at the Central Bank of Argentina, Dartmouth College, the Federal Reserve Bank of Boston, the Federal Reserve Board, the Inter-American Development Bank, Tufts University, Universidad San Andres, Wellesley College, Wesleyan University, and the World Bank Research Department. Finally, I would like to express my gratitude to Matthew Jones and Gretchen Weinbach for their help with the empirical estimations of the EM algorithm.
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1- Introduction

In recent years, both developed and developing countries have experienced speculative attacks on their currencies. The European Monetary System (EMS) was severely undermined by intense speculative pressure in 1992-93, which led to the exit of Britain and Italy in 1992 and the widening of the Exchange Rate Mechanism (ERM) band in 1993. In December 1994, following a speculative attack on the Mexican peso, the crawling peg was abandoned and the currency devalued. More recently, turbulence in financial markets has crippled many Asian currencies as well as the Russian ruble.

This recent wave of speculative attacks and devaluations has rekindled interest in the subject. The conventional wisdom is that speculative attacks refer to episodes where currencies come under severe pressure to be devalued. These episodes may or may not result in devaluations. For example, governments faced with speculative pressure can try to avoid devaluations by selling reserves and/or by raising interest rates.

Most papers in the literature of speculative attacks pursue a two step approach to identify and to study the determinants of speculative attacks (see Eichengreen, Rose, and Wyplosz (1995, 1996), Frankel and Rose (1996), and Kaminsky and Reinhart (1996) among others). First, they identify speculative attacks by constructing indices of speculative pressure. These are weighted averages of changes in exchanges rates, interest rates, and reserves. A given episode is classified as a speculative attack if the index is above a certain threshold. Based on this classification, a zero/one variable is constructed, which identifies the speculative attack episodes in the sample. Second, an analysis of the determinants of the likelihood of a speculative attack is conducted by estimating logit or probit models where the zero/one variable discussed above is used as the dependent variable.

This paper proposes a different approach to study speculative attacks. Fixed exchange rate regimes are typically characterized by periods of relative calm punctuated by short and sharp periods of speculative attacks. Given the nature of fixed exchange rate systems, this paper implements a regime-switching model with time-varying transition probabilities to, simultaneously, identify speculative attacks and study the determinants of switching to speculative regimes.

Though regime shifts are not directly observable, we can draw probabilistic inferences on these episodes from the behavior of observable variables. In particular, speculative attacks are characterized by: sharp falls in reserves, depreciations of the exchange rate, and/or increases in interest rates.[1] Thus, this paper identifies speculative attacks by modeling reserves, exchange rates, and interest rate differentials as time series subject to discrete shifts in regimes. In other words, we assume the behavior of these variables is different depending on the state in which the economy resides. We assume a "tranquil" state where the variables above are stable, and a "speculative" regime characterized by large depreciations of exchange rates, reserve falls, interest rate hikes, and/or an overall increase in the volatility of these variables.

The approach pursued in this paper is in the spirit of Hamilton's (1990) regime-switching model where a vector of parameters is allowed to switch, potentially every period, depending on which of two unobserved states is realized. In Hamilton's framework, state transitions are governed by a first-order Markov process and the probabilities assigned to switching or staying in a given state (called transition probabilities) are assumed to be constant. However, because the assumption of constant transition probabilities is very restrictive, and because we would like to know what drives these probabilities, this paper adopts the algorithm proposed by Diebold, Lee,

[1] When a currency comes under attack, the government can allow the currency to depreciate, lose reserves while

and Weinbach (1994). This algorithm allows transition probabilities to be time-varying functions of observable variables.

Following the literature on speculative attacks and devaluations, we model transition probabilities as logistic functions of economic fundamentals à la Krugman (1979).[2] Also, we include expectations' proxies such as interest rate differentials and survey data on expected exchange rates to allow for the possibility that expectations drive speculative attacks.

The regime-switching approach (with time-varying transition probabilities) proposed here to study speculative attacks has two main advantages. First, this method of identifying attacks avoids the arbitrariness involved in the construction of indices of speculative pressure. To construct an index of speculative pressure it is necessary to determine which variables to include and what weights should be given to each variable. Instead, in the regime-switching approach, the parameters estimated in the model and the data reveal the state (tranquil or speculative) in which the economy resides at each point in time. The second main advantage of the regime-switching approach is that it can directly address the question of what causes shifts from and to periods of speculative attacks. In particular, by modeling transition probabilities as a function of fundamentals and expectations, we are able to study the determinants of speculative attacks.

This paper implements the regime-switching approach to study speculative attacks on EMS currencies during the period 1979-1993. We estimate two switching models. In the first case, changes in the exchange rate alone are associated with the unobserved regimes. Thus, in this first model, speculative attacks manifest as realignments or as significant depreciations of the exchange rate. The second model is a VAR switching model of changes in exchange rates,

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keeping the exchange rate fixed, and/or raise interest rates to deter speculation.

[2] These fundamentals include: the growth of domestic credit, the ratio of imports to exports, the real exchange rate, the unemployment rate, and the fiscal deficit.

reserves, and interest rate differentials. In this model, all three variables are affected by the state (speculative or tranquil) in which the economy resides at any point in time. In both models, we allow transition probabilities to be a function of fundamentals and expectations.

The rest of the paper is organized as follows. Section 2 reviews the theoretical and empirical literature on speculative attacks. Section 3 briefly summarizes previous empirical studies on exchange rates that estimated switching models. Section 4 discusses the empirical approach pursued in this paper. Section 5 describes the data used in this study. Section 6 presents the empirical results obtained. Section 7 examines the question of how well the switching approach captures attacks. Finally, section 8 concludes.

2- The literature on speculative attacks

Two types of models, the so-called "first generation" and "second generation" models, dominate the existing literature on the determinants of speculative attacks and devaluations. The first generation models (see Krugman (1979) and Flood and Garber (1984a) among others) emphasize the relationship between speculative attacks and economic fundamentals. According to these models, countries suffer attacks when they run unsustainable monetary and fiscal policies.

In Krugman's (1979) seminal article the balance of payments crisis is driven by an exogenous budget deficit financed by monetary expansion. The model developed by Krugman has been extended in various ways. Relaxing his assumption of purchasing power parity for example, shifts to expansionary policies increase the demand for domestic goods, causing their price to rise and leading to real exchange rate appreciations prior to attacks. In turn, the trade deficit is likely to grow before attacks due to the appreciation in the real exchange rate.

Recent theoretical research on speculative attacks has deviated from the external balance fundamentals to focus on how internal balance factors can cause speculative attacks. For example, Ozkan and Sutherland (1994) expand the set of relevant fundamentals associated with attacks to include internal balance factors like the unemployment rate. In their model, there may be no evidence of monetary or fiscal imbalances prior to the attack. However, the authors assume that the policies implemented by the government, which are consistent with the exchange rate peg, increase unemployment. They argue that if the government's survival probability falls as unemployment rises, and if switching to more expansionary policies reduces unemployment, the government may be forced to abandon the peg.[3]

The second generation models (see Obstfeld (1986, 1994), Flood and Garber (1984b) among others) allow speculative attacks to be self-fulfilling. Thus, in these models expectations play a crucial role in bringing about speculative attacks. If no speculative attack takes place, government policies are consistent with the exchange rate peg and the peg is maintained. However, if and only if an attack occurs, government policies become more accommodating, causing the exchange rate to depreciate. Thus, given the policies pursued by the authorities following the attack, the attack is rational.

The empirical literature on currency crises has mostly focused on the study of discrete devaluations in developing economies.[4] Blanco and Garber (1986), Cumby and Van Wijnbergen (1989), and Goldberg (1994) estimate one-period ahead probabilities of devaluations derived from structural models in the flavor of Krugman's model. These papers study devaluations in Argentina (in 1981) and Mexico (in 1982 and in 1986), respectively. Edwards (1989), Klein and

[3] To the extent that the rise in unemployment is due to the government's effort to defend from a speculative attack by rising interest rates, this model can also be considered as an example of self-fulfilling crises.
[4] For a comprehensive review of the empirical literature on speculative attacks see Kaminsky, Lizondo, and Reinhart (1997).

Marion (1997), and Martinez Peria (1997) use probit and logit models to estimate likelihoods of devaluations as a function of economic fundamentals in developing countries, in the first case, and Latin American economies, in the last two cases. Though the studies mentioned above are valuable, they have a number of limitations. They only consider devaluations as opposed to speculative attacks in general.[5] They do not allow expectations to play a role in explaining speculative attacks. Finally, they restrict their analysis of the determinants of currency devaluations to the case of developing countries.

While the studies above have attempted to characterize devaluations exclusively, fewer studies have analyzed a broader class of crises, namely speculative attacks where devaluations may be averted at the expense of sizeable losses in reserves and/or large increases in interest rates. Eichengreen, Rose, and Wyplosz (1995, 1996), ERW hereafter, Kaminsky and Reinhart (1996), and Frankel and Rose (1996) are the main contributors to this literature. These studies construct indices of speculative pressure to identify attacks against developed and developing countries' currencies. These indices are weighted averages of reserve, exchange rate, and interest rate differential changes. When the index is above a certain threshold (e.g. two standards deviation above the mean) the associated period is classified as a speculative attack episode. An important limitation of the speculative index approach is that the weights assigned to the components of the index, as well as the threshold used to identify speculative attacks, are largely arbitrary. Consequently, the methodology used to classify observations may be quite ad-hoc.

Surprisingly, even fewer studies have systematically analyzed the determinants of ERM currency crises.[6] Eichengreen, Rose, and Wyplosz (1995, 1996) and Ötker and Pazarbaşioğlu

[5] As defined earlier, by speculative attacks we mean not only devaluations, but also instances where a devaluation was averted at the expense of large losses in reserves or interest rate hikes.
[6] Studies like Caramazza (1993), Chen and Giovannini (1993), and Rose and Svensson (1994) have analyzed realignment expectations, but not the more fundamental issue of what determines actual probabilities of attacks or

(1997) study speculative attacks and realignments, respectively, in the context of the ERM.[7] In ERW (1995), the authors examine a sample of 20 industrial countries throughout 1959-1993, including most ERM countries. Speculative attack episodes are identified by an index of speculative pressure. The authors construct this index as a weighted average of changes in exchange rates, reserves, and interest rate differentials. The weights assigned to each variable are such that all variables have the same variance. They use logit analysis to study the determinants of the probability of speculative attacks. Overall, the authors find that the unemployment rate, government budget deficit, and domestic credit are unrelated to exchange rate episodes.

ERW (1996) conduct a non-parametric analysis of speculative attacks in 22 countries during the period 1967-1992. Once again, the authors construct an index of speculative pressure to identify attacks. This paper finds that the behavior of fundamentals in ERM crises periods is not significantly different to that in non-crises periods. They interpret this evidence as a departure from the first generation models of attacks. However, when they examine realignments only (rather than speculative attacks in general), they find evidence that fundamentals deteriorate prior to these episodes. They conclude that "governments historically chose to realign ERM currencies on the basis of standard macroeconomic criteria but that speculators chose to attack ERM currencies for other reasons".

While the work by ERW mentioned above is very informative, these studies define crises on the basis of indices which involve a large degree of arbitrariness in their construction. Also, in analyzing the determinants of currency crises, the authors ignore any direct role that expectations might play in bringing about speculative attacks.

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devaluations.

[7] Jeanne (1997) develops a model of a fixed exchange rate in which self-fulfilling expectations and fundamentals may complement each other in causing currency crises. The model is estimated specifically for the case of the 1992-93 crisis of the French franc. The author finds evidence of self-fulfilling speculation at work.

Ötker and Pazarbaşioğlu (1997) use probit analysis to estimate the probability of devaluations in a sample of ERM countries during the period 1979-1995.[8] The authors test for the role of speculative factors (like interest rate differentials and the position of the exchange rate within the band) and fundamentals (like domestic credit, budget deficits, trade balances, and unemployment rates) in bringing about devaluations or realignments of the currencies involved. Overall, the paper finds that both economic fundamentals and speculative factors contribute to the devaluations of ERM currencies. This paper takes a step in the right direction by allowing for the possibility that devaluations result from speculative factors, and not only from deteriorating fundamentals. However, the analysis in this paper is too restrictive since it only studies devaluations or realignments. Also, the authors examine the role of speculative factors and fundamentals separately rather than jointly, as it would be necessary to draw any inferences regarding their relative impact on the likelihood of devaluations.

The approach developed in the remaining of this paper tries to address some of the limitations in the existing empirical literature on speculative attacks. First, the methodology suggested to identify attacks avoids the use of indices of speculative pressure. Second, in evaluating the likelihood of attacks, this study allows expectations to have a direct role on the likelihood of switching from periods of tranquility to periods of speculative pressure. In other words, measures of expectations are included along with economic fundamentals in the estimation of switching probabilities.

[8] The countries included are: Belgium, Denmark, France, Ireland, Italy, and Spain.

3- The empirical literature on switching models applied to exchange rates

Most of the empirical papers that estimate switching models apply Hamilton's (1990) switching model or a variant of this model. In Hamilton's framework, time series dynamics are governed by a finite-dimensional parameter vector, which switches (possibly every period) depending upon which of two states is realized. State transitions are governed by a first-order Markov process with constant transition probabilities.[9] Diebold, Lee, and Weinbach (1994), develop a variant of the Markov switching model in which transition probabilities are endogenous. In other words, in Diebold et al. the probabilities of switching regimes depend on time-varying regressors.

A number of recent studies have used Hamilton's Markov switching model, or the Diebold et al.'s variant, to study the behavior of exchange rates.[10] Engel and Hamilton (1990) estimate a two-state Markov switching model with constant transition probabilities to explain the behavior of the U.S. dollar against the German mark, the French franc, and British pound over the period 1973-1988. They find that the switching model outperforms the popular random walk model of exchange rates. Weinbach (1995) extends the work of Engel and Hamilton to the time-varying transition probability case.[11]

Switching models have also been used to analyze the behavior of semi-fixed exchange rates. Engel and Hakkio (1996) use Hadi's method of identifying outliers to show that EMS exchange rates over the period 1979-1993 seem to be drawn from a mixture of distributions, one

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[9]Let S_t be a random variable that can assume only two integer values {0,1}. Suppose that the probability that S_t equals some particular value j depends on the past only through the most recent value S_{t-1}: $P\{S_t=j/S_{t-1}=i,S_{t-2}=j,....\}=P\{S_t=j/S_{t-1}=i\}=pij$. Such a process is described as a 2-state first order Markov process.

[10] For a discussion on the use of switching models to study business cycles see Filardo (1994) and Ghysels (1994). Jones (1997) implements a time-varying regime-switching model to study lender of last resort credibility for the U.S.

[11] Weinbach allows dollar exchange rate switches between periods of appreciation and depreciation to be a function of market fundamentals.

with high variance (which coincides with speculative attacks and realignments) and one with low variance. Given this evidence, and since the volatile periods tend to be clustered together, they fit a regime-switching model to study the behavior of EMS exchange rates. They model the probability of switching between states as a function of the distance of the exchange rate from the upper band. They find that the probability of staying in a volatile state increases, the closer is the exchange rate to the top of the band.

Relative to the papers discussed above, Hsieh (1994) is the most related to this study. He estimates an AR(4) version of Hamilton's switching model to identify speculative attacks against EMS currencies in the period 1979-1993. He models the behavior of the components of Eichengreen et al.'s index of speculative pressure as time series subject to discrete shifts in regime. That is, exchange rates, reserves, and interest rate differentials of EMS countries are assumed to switch between periods of tranquility and periods of speculative attacks. As in the original Hamilton model, he assumes that transition probabilities are constant over time. Attacks are identified as periods where the probability of a speculative attack is almost one. Hsieh finds that the switching model captures most of the attacks identified by Eichengreen et al., as well as actual realignments.

Hsieh's objective is exclusively to identify periods of speculative pressure by using a regime-switching methodology and to compare these episodes with those captured by ERW's index. On the other hand, this paper attempts both to identify attacks and to study their determinants. Similarly to Hsieh, we model the components of the Eichengreen et al.'s index as autoregressive time series subject to shift in regimes. However, while Hsieh only assumes the mean and variance to be different across regimes, the models estimated here also allow the coefficients on the autoregressive terms to be potentially different across regimes. Therefore, these models yield greater flexibility. Also, instead of identifying attacks by fitting only separate switching models to exchange rates, reserves, and interest rate differentials, this paper estimates a VAR switching model, which allows for the more realistic case that attacks are associated with the behavior of the three variables combined. Furthermore, while in Hsieh's study transition probabilities are constant over time, this paper allows transition probabilities to and from speculative attack regimes to be driven by both economic fundamentals and expectations. Thus, this enables us to analyze explicitly the determinants of speculative attacks.

4- Empirical Estimation Approach

Speculative attacks are typically associated with significant depreciations of the exchange rate. However, attacks can also result in sharp falls of reserves or increases in the interest rate differential, depending on the policy pursued by the government at the time of the attacks. For example, the exchange rate might depreciate if the government is not willing to lose reserves or to raise interest rates to defend the currency. Alternatively, if the government is determined to maintain a fixed parity or band, it might be willing to sell reserves or even increase interest rates to deter the outflow of reserves. Finally, if the government is concerned with the impact of high interest rates on unemployment or on the health of the banking system, it will be forced to see reserves fall or it will have to abandon its exchange rate objective. Therefore, at a given point in time, a speculative attack can be associated with a depreciation of the exchange rate, a fall in reserves, and/or an increase in interest rates. On the other hand, these three variables are typically stable during periods of tranquility. Consequently, it follows that reserves, exchange rates, and interest rates exhibit a different behavior in periods of tranquility than in periods of speculative attacks.

This paper identifies speculative attacks by modeling exchange rates, reserves, and interest rate differentials as time series subject to discrete shifts in regime. In particular, this paper estimates two regime-switching models to identify attacks and to study the determinants of switching to speculative regimes. In the first model, attacks are identified by modeling exchange rates only as time series subject to regime changes. In the second model, we adopt a VAR switching structure to allow speculative attacks to be associated with regime shifts in reserves, exchange rates, and/or interest rates differentials. In both models, we assume time-varying transition probabilities that are logistic functions of fundamentals and expectations.

Model 1: Exchange rate switching model

We assume exchange rate changes, Δe_t, follow the process below[12]:

$$\Delta e_t = \alpha_{S_t 0} + \alpha_{S_t 1}[\Delta e_{t-1}] + \alpha_{S_t 2}[\Delta e_{t-2}] + \alpha_{S_t 3}[\Delta e_{t-3}] + \alpha_{S_t 4}[\Delta e_{t-4}] + \sigma(s_t)\,\varepsilon_t \quad (1)$$

where ε_t is an i.i.d N(0,1) variable.

Equation (1) states that exchange rate changes behave differently depending on the value of S_t. We assume exchange rates changes follow an AR(4) process.[13] However, the mean, variance, and autoregressive parameters of the exchange rate equation depend on the state in which the economy resides. S_t is an unobserved zero/one variable which characterizes the regime the economy is in, and consequently, the process the exchange rate will follow on date t. That is, there are two possible regimes, a "tranquil" regime (which corresponds to S_t=0) where the parameters and the variance of the exchange rate equation are such that the exchange rate

[12] The exchange rate variable mentioned above is in fact the percentage change in the exchange rate of each currency with respect to the Deutsche mark.
[13] This follows the analysis conducted by Hsieh (1994).

remains stable, and a "speculative attack" regime (where S_t=1) characterized by large depreciations of the exchange rate and high volatility.

In Hamilton's framework, S_t follows a first-order two-state Markov process with transition probabilities given by:

$$P(s_t = 1/ s_{t-1} = 1) = p^{11} \qquad (2)$$

$$P(s_t = 0/ s_{t-1} = 1) = 1 - p^{11} = p^{10} \qquad (3)$$

$$P(s_t = 0/ s_{t-1} = 0) = p^{00} \qquad (4)$$

$$P(s_t = 1/ s_{t-1} = 0) = 1 - p^{00} = p^{01} \qquad (5)$$

Equations (2)-(5) list the probabilities of being in either of the two states, given the state realized in the previous period. For example, the probability of a tranquil state (S_t=0) on date t, given a tranquil state in the previous period (S_{t-1}=0) is a constant p^{00}. Similarly, the probability of a tranquil state on date t, given a speculative attack in the previous period is a constant p^{10}.

A limitation of Hamilton's model is that transition probabilities are fixed. That is, the probability of a particular state, given the state realized in the previous period, is constant over time. Thus, we adopt a variant of Hamilton's model developed by Diebold et al. (1994) in which the transition probabilities given in equations (2)-(5) are time-varying. In particular, these probabilities are estimated as logistic functions of a conditioning matrix X_{t-1}, as shown in equations (6)-(9).

$$p_t^{00} = P(s_t = 0/ s_{t-1} = 0, x_{t-1}; \beta_0) = \frac{\exp x_{t'-1}\beta_0}{1 + \exp x_{t'-1}\beta_0} \qquad (6)$$

$$p_t^{11} = P(s_t = 1/ s_{t-1} = 1, x_{t-1}; \beta_1) = \frac{\exp x_{t'-1}\beta_1}{1 + \exp x_{t'-1}\beta_1} \qquad (7)$$

$$p_t^{01} = (1 - p_t^{00}) = P(s_t = 1 / s_{t-1} = 0, x_{t-1}; \beta_0) = 1 - \frac{\exp x_{t'-1}\beta_0}{1 + \exp x_{t'-1}\beta_0} \quad (8)$$

$$p_t^{10} = (1 - p_t^{11}) = P(s_t = 0 / s_{t-1} = 1, x_{t-1}; \beta_1) = 1 - \frac{\exp x_{t'-1}\beta_1}{1 + \exp x_{t'-1}\beta_1} \quad (9)$$

By allowing transition probabilities to vary over time, we can model the mechanics underlying shifts from tranquil to speculative attack regimes explicitly. In particular, we use this framework to determine whether economic fundamentals and/or expectations have any effect in bringing about shifts to speculative attack regimes.

Given the literature on speculative attacks described in section 2, we include the following variables as potential determinants of the transition probabilities (i.e. the variables to be included in the matrix X_{t-1}): growth of domestic credit, ratio of imports to exports, unemployment rate, fiscal deficit, and interest rates. We express all of these variables as differentials with respect to the corresponding German variable.[14] The ratio of imports to exports is used as a proxy of the current account deficit. We also include a real exchange rate index to capture the possible deterioration in the competitiveness of a country against Germany. The interest rate differential is incorporated in the estimation of the transition probabilities as a measure of expectations. In other words, assuming uncovered interest parity, interest rate differentials capture expectations of exchange rate depreciations.

Following Diebold et al., we adopt the EM algorithm to obtain maximum likelihood estimates of all the parameters in model 1. In general, the EM algorithm maximizes the incomplete-data log likelihood (that for $\{\Delta e_t\}$ alone) via the iterative maximization of the expected complete-data log likelihood (that for $\{\Delta e_t\}$ and $\{s_t\}$), conditional upon the observable

[14] The reason why we measure all variables relative to Germany is because though the EMS during the period 1979-1993 was in principle a symmetric system, Germany was in fact the anchor country. All realignments within the EMS implied devaluations of the currencies with respect to the Deutsche mark.

data. Given the observed data and some initial estimate of the parameters in the model, the EM algorithm begins by calculating the smoothed state probabilities (i.e. the unconditional probability of a particular state). With the estimated smoothed state and transition probabilities, the expected complete-data log likelihood function is constructed. This is the "E", expectation part of the algorithm. The expected complete-data log likelihood function is then maximized to obtain an updated parameter estimate. This is the "M", maximization part of the algorithm. Using this updated estimate, the smoothed probabilities are calculated again and substituted into the expected likelihood function, which is maximized again. This procedure is repeated until convergence (in the parameter estimates or the likelihood function) is obtained.[15]

Model 2: VAR switching model

Though most speculative attacks result in sizeable devaluations, attacks can also be associated with substantial losses in reserves, and/or increases in interest rate differentials. Consequently, it is appropriate to identify speculative attacks taking into account the behavior of these three variables.

In this model, we assume that changes in exchange rates (Δe_t), reserves (Δr_t), and interest rate differentials (Δid_t) behave according to the following VAR switching structure:

$$\Delta e_t = c_{St}^{\Delta e} + \alpha_{St}^{\Delta e}[\Delta e_{t-1}] + \delta_{St}^{\Delta e}[\Delta r_{t-1}] + \gamma_{St}^{\Delta e}[\Delta id_{t-1}] + \sigma(S_t)u_t^{\Delta e} \quad (10)$$

$$\Delta r_t = c_{St}^{\Delta r} + \alpha_{St}^{\Delta r}[\Delta e_{t-1}] + \delta_{St}^{\Delta r}[\Delta r_{t-1}] + \gamma_{St}^{\Delta r}[\Delta id_{t-1}] + \sigma(S_t)u_t^{\Delta r} \quad (11)$$

$$\Delta id_t = c_{St}^{\Delta id} + \alpha_{St}^{\Delta id}[\Delta e_{t-1}] + \delta_{St}^{\Delta id}[\Delta r_{t-1}] + \gamma_{St}^{\Delta id}[\Delta id_{t-1}] + \sigma(S_t)u_t^{\Delta id} \quad (12)$$

[15] See Diebold et al. (1994) for a detailed description of the EM algorithm and for the closed form solutions of the maximum likelihood estimates of the parameters.

where $u_t^{\Delta e}$, $u_t^{\Delta r}$, and $u_t^{\Delta id}$ are i.i.d. N(0,1) variables and the superscripts ${}^{\Delta e}$, ${}^{\Delta r}$, and ${}^{\Delta id}$ indicate the equation to which the parameters belong to.

Once again, S_t is an unobserved zero/one variable that characterizes the regime in which the process is in, on date t. As before, there are two possible regimes: a "tranquil" regime and a "speculative attack" regime that is characterized by large depreciations of the exchange rate, sharp falls in reserves, and/or increases in the interest rate differential. The process described in equations (10) through (12) differs from a standard VAR(1) specification in that the constant term, the parameters on the lagged values of exchange rates, reserves, and interest rate differentials, as well as the error term variances, are functions of the regime at the time. Thus, we can think of the VAR above as really two VARs, one that holds when $S_t=0$ and one that determines, Δe_t, Δr_t, and Δid_t when $S_t=1$.

Similarly to the exchange rate switching model, we allow transition probabilities between periods of tranquility and speculative attacks to vary over time. These probabilities follow equations (6) through (9) above. In fact, we model these probabilities to be a function of the same X_{t-1} matrix that determines transition probabilities in the exchange rate switching model. In other words, we assume that transition probabilities are a function of differential (domestic minus German) growth of domestic credit, ratio of imports to exports, unemployment rates, fiscal deficit as a percentage of GDP, and interest rates. Also, a real exchange rate index is included to capture changes in competitiveness.

The parameters in this model are also estimated using the EM algorithm outlined above. For computational convenience, equations (10)-(12) are transformed using a Cholesky decomposition so that the model's variance-covariance matrix becomes diagonal. This allows the likelihood function for the model to be the product of the likelihood functions of each of the three equations. Given that we are not concerned with the actual parameters in these equations, but only with the fact that the parameters in each equation are different across states, this transformation is harmless. Since there is a one to one relationship between the triangular and non-triangular versions of the VAR, and given that the coefficients in the transition probabilities are the same in both normalizations, their estimates are unaffected.

5- The Data

We use the empirical methodology described above to identify and to study the nature of speculative attacks in ERM member countries between 1979 and 1993. The following countries are included in the sample: Belgium (1979-93), Denmark (1979-93), France (1979-93), Ireland (1979-93), Italy (1979-92), Spain (1989-93), and the UK (1990-92). Most variables for these countries are measured as differences or ratios to the corresponding German values.

Monthly data for this study were obtained from the IMF's International Financial Statistics and the OECD's Main Economic Indicators publications. Survey data on expected exchange rates came from the Currency Forecasters Digest, a Financial Times publication.

6- Empirical results

The results in this paper, both for the exchange rate and the VAR switching models, are obtained by pooling the data for all countries in the sample. The observations considered for each country span the period since the respective country joined the ERM through August 1993, when the ERM band was significantly widened. Pooling the data is necessary because the number of switches (or speculative attacks) for each country is small relative to the number of parameters to be estimated in a model where transition probabilities are time-varying. In other words, given a limited number of switches per country, it is impossible to estimate transition probabilities as a function of multiple regressors unless we pool the data.

Results from the exchange rate switching model

Table 1 contains the parameter estimates of the switching model based on monthly percentage changes in the exchange rate during the period 1979-1993. Model (1.1) presents the estimates of the constant transition probability version of the exchange rate switching model (i.e. the Hamilton version model). Model (1.2) refers to the estimates from the exchange rate switching model with time-varying transition probabilities. This is Diebold et al.'s variant of the switching model. As noted earlier, the main reason to estimate this model is to allow for the possibility that the probability of switching from a period of tranquility to a speculative regime may be driven by fundamentals and/or expectations. In these estimations, the interest rate differential is used as a proxy of exchange rate expectations. Model (1.3) is the same as (1.2) except that we include dummy variables to control for country fixed effects.

We estimate model (1.1), the Hamilton version of the exchange rate switching model, to test two hypotheses. The first one is the null of no switching. We perform this test by comparing the log likelihood function from a model where the autoregressive parameters are constrained to be equal across states against the alternative shown in model (1.1), where we allow these parameters to be different across states.[16,17] α_{00}-α_{04} refer to the constant and autoregressive

[16] The problem of testing the hypothesis of no switching is that under the null the parameters in the transition probabilities become nuisance parameters. When this happens, we cannot assume the standard distributions to conduct our tests. To circumvent this problem we follow Engel and Hamilton (1990) in their "approximate" test of no switching. What the authors do (and we follow them) is to test whether the autoregressive parameters are the same across states, while allowing the variance of exchange rates to be different in different states. We also conduct the opposite test, where the autoregressive parameters change across states, but the variances are assumed constant across regimes.

[17] We do not show the results for the Hamilton version of the model where the autoregressive parameters are

parameters for the tranquil state, while α_{10}-α_{14} are the corresponding parameters for the speculative state. At 5 percent significance, we reject the hypothesis of equal alpha parameters across states. That is, we reject the null that α_{00}-α_{04} =α_{10}-α_{14}.[18] This provides evidence that the exchange rate is drawn from two regimes as we assume.

The second hypothesis we test, involving the Hamilton version of the model, is whether fundamentals and expectations play a significant role in determining transition probabilities. The null hypothesis considered (i.e., β_{01}-β_{06}=β_{11}-β_{16}=0 from equations (6)-(9)) is a test of the validity of the Hamilton constant probability version of the model (i.e., model (1.1)) versus Diebold et al.'s time-varying transition probability specification (i.e., model (1.2)). At 5 percent significance, we reject the null that the constant transition probability model is the true model.[19] Therefore, the results indicate that fundamentals and expectations significantly affect the likelihood of switching to and from speculative attack periods.

Regarding the transition probabilities' parameters, β_{00}-β_{06} enter with a positive sign in the equation for p_t^{00}, the probability of staying in a tranquil state given that the previous period was also a tranquil one (see equation (6)). On the other hand, β_{00}-β_{06} negatively affect the complement of p_t^{00}, p_t^{01}, the probability that a speculative attack will follow a period of tranquility (see equation (8)). The results in model (1.2) indicate that an increase in the trade deficit, an appreciation in the real exchange rate, and an increase in the interest rate differential have a negative impact on the probability of staying in a period of tranquility. Alternatively, an

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constrained to be equal across states because we do not have an interest in these parameters individually. The only reason behind the estimation of this model for our purposes is to test the hypothesis of no switching.

[18] The likelihood ratio test statistic is 54.52. The 5 percent significance level critical chi value for this test is 9.49. Therefore, we reject the null of no switching at 5 percent significance.

[19] The likelihood ratio test statistic is 51.97. The 5 percent significance level critical chi value for this test 21.83. Therefore, the null is rejected at 5 percent significance level.

increase in these variables has a positive effect on the probability of switching from a period of tranquility to a speculative attack. Only the interest rate differential has a statistically significant effect. Since the interest rate differential is a proxy for expectations, the fact that this variable is significant indicates that agents' expectations of devaluations can play an important role in causing speculative attacks against a currency. This result is consistent with the predictions from models of self-fulfilling attacks.

The growth of domestic credit, the unemployment rate, and the government surplus have a positive effect on the probability that a state of tranquility will follow a period of tranquility, or alternatively, a negative impact on the likelihood of switching from a period of tranquility to a speculative regime. The first two variables are insignificant and have opposite signs to those predicted by a model of speculative attacks caused by fundamentals. On the other hand, the government surplus as a percentage of GDP has the expected sign and is individually statistically significant. As predicted by the first generation models, the results indicate that larger government deficits increase the probability of switching from periods of tranquility to speculative attack episodes.

The parameters β_{10}-β_{16} in model (1.2) affect p_t^{11}, the probability that a speculative state will follow a speculative state, and its complement, p_t^{10}, the probability of switching to a tranquil state given a speculative attack in the previous period. No regressor affecting p_t^{11} and therefore, p_t^{10}, is significant. A possible explanation for this result (which will be illustrated in section 7) is that speculative attacks are rare, short-lived events. Therefore, with very few and brief speculative episodes, it is hard to estimate the significance of any particular parameter.

[Table 1 here]

Model (1.3) in Table 1 presents the results obtained when we include dummy variables in the estimation of the transition probabilities to control for country fixed effects. Therefore, model (1.3) is identical to model (1.2), with the exception that country dummies are added to this latter specification. Given that no dummy is individually significant, we do not report their coefficient estimates here. However, at 5 percent significance, a likelihood ratio test rejects the null that country-fixed effects are jointly zero.[20]

When dummies are included, the parameter estimates for the transition probabilities do not change significantly. As in model (1.2), only the interest rate differential and the government surplus (as a % GDP) have a significant impact on p_t^{00} and its complement, p_t^{01}, the likelihood of switching from a period of stability to a speculative attack. The interest rate differential has a negative impact on p_t^{00} and, consequently, as expected, a positive impact on p_t^{01}. Thus, the larger the interest rate differential, the greater the expectations that a speculative attack might occur, and, therefore, the larger the probability of switching from a tranquil period into a speculative attack regime. On the other hand, the larger the government surplus, the smaller the probability of switching from a period of tranquility to a speculative regime.

Results from the VAR switching model

Table 2 below presents the estimates from the VAR switching model outlined in equations (10)-(12) plus the transition probabilities parameters of equations (6)-(9). For computational convenience, we estimate the Choleski transformed version of equations (10)-(12).

[20] The likelihood ratio test statistic is 46.5. The 5 percent significance level critical chi value for this test is 23.69. Therefore, the null is rejected at 5 percent significance.

The VAR switching model allows us to identify and examine the determinants of crises defined in a broader sense than in the exchange rate switching model. In the case of the latter, we identified as speculative attacks episodes, periods of large depreciations or realignments of the exchange rate. With the VAR switching model, we identify as speculative attacks, periods of large depreciations of exchange rates, large drops in reserves, and/or significant interest rate increases. Thus, in the VAR model, we allow for the possibility that countries defend from pressures to devalue their currencies by raising interest rates or selling reserves.

Model (2.1) in Table 2 presents the Hamilton version of the VAR switching model where transition probabilities are constant across regime. Model (2.2) corresponds to the estimation of the VAR switching model with time-varying transition probabilities. Model (2.3) is identical to model (2.2) except that the former includes country dummies.

The purpose of estimating the Hamilton version of the VAR switching model (model (2.1)) is twofold. In the first place, we estimate this model to test the null of no switching in exchange rates, reserves, and interest rate differentials.[21] In other words, we conduct a likelihood ratio test to compare model (2.1) against a specification where we constrain the parameters in the VAR equations to be equal across states.[22] At 5 percent significance, we reject the null hypothesis of no switching.[23]

Secondly, we estimate model (2.1) to test the null hypothesis of constant transition probabilities against the preferred hypothesis that transition probabilities vary over time. This involves testing model (2.1) against model (2.2). At the 5 percent significance level, we reject

[21] The test conducted here is only an approximation to the true test of no switching. See footnote 16.
[22] The results from the constrained VAR switching model are not shown here, but are available upon request.
[23] The likelihood ratio test statistic is 45.34. The 5 percent significance level critical chi value for this test is 25. Therefore, the null is rejected at 5 percent significance level.

the null hypothesis of constant transition probabilities.[24] Thus, the time-varying transition probability model, i.e., model (2.2), is better suited than the Hamilton model to study speculative attacks and their determinants.

[Table 2 here]

Regarding the determinants of the transition probabilities in model (2.2), at 5 percent significance, we can reject the hypothesis that these are jointly insignificant. Thus, fundamentals and expectations determine the likelihood of switching from and to periods of speculative attacks. However, no variable is individually significant.

Model (2.3) is the same as model (2.2) with the exception that the former includes country dummy variables to control for country fixed effects. We find that country dummies are jointly significant, but none of them are individually significant.[25] Once we allow for country fixed effects, we find that the government budget deficit plays a significant role in determining the likelihood that a country will switch from a state of tranquility to a speculative attack period.

Finally, Table 3 below compares the result from the estimation of the VAR switching model using survey data on expected exchange rates, with the results using interest rate differentials to capture expectations. The purpose of this exercise is to analyze whether the results we obtained regarding the determinants of the transition probabilities are sensitive to the choice of expectations proxy we use. Because survey data on expected exchange rates is available since February 1988, we can only estimate the model for the period 1988-1993. Given that we are primarily interested in the effect that expectations have on the probabilities of

[24] The likelihood ratio test statistic is 23.82. The 5 percent significance level critical chi value for this test is 21.03. Therefore, the null is rejected at 5 percent significance.
[25] The likelihood ratio test statistic is 40. The 5 percent significance level critical chi value for this test is 23.64. Therefore, at 5 percent significance we reject the null that the country dummies are jointly zero.

switching to and from speculative regimes, we only report the parameters affecting these probabilities.

[Table 3 here]

Both the interest rate differential and the expected exchange rate have a negative impact on the probability of staying in a period of tranquility or, equivalently, a positive effect on the probability of switching from a period of tranquility to a speculative attack. However, neither of these two expectations proxies are significant. Also, no other variable is individually significant in explaining switching probabilities for the period 1988-1993, although once again we find that fundamentals and expectations are jointly significant.

The fact that nothing seems to be explaining the EMS crises over the period 1988-1993 is consistent with what other authors have found. Rose and Svensson (1994), for example, find that realignment expectations remained fairly constant throughout this period. Similarly, Eichengreen and Wyplosz (1993) argue that there is weak evidence that the 1992-93 EMS crises were the result of deteriorating economic fundamentals.

Finally, there can be a purely statistical reason explaining why no variable has an individually significant effect on the likelihood of switching to a speculative attack during 1988-93. Given that this period was in general a tranquil one, with the exception of the 1992-93 crises, it is possible that there are only a few regime switches in the data to identify all the parameters in the model. This may lead to inefficient estimates and, therefore, may explain why no regressor is individually significant during this period.

7- How well do the switching models with time-varying transition probabilities track speculative attacks?

From the estimation of the exchange rate and the VAR switching models, it is possible to recover the estimated probability of a speculative attack at each point in time, given the observable data.[26] Figures A.1.a-A.14.a included in the appendix, display the unconditional smoothed probabilities that the economy resided in a speculative state according to the exchange rate (figures A.1.a-A.7.a) and VAR (figures A.8.a-A.14.a) switching models. Figures A.1.b-A.14.b in the appendix show the estimated probability of switching from a period of tranquility to a speculative regime. These correspond to the transition probability labeled p_t^{01} in equation (8).

From Figures A.1.a-A.14.a, it is clear that most of the estimated probabilities of speculative attacks are either close to zero or one. Also, these probabilities move rapidly between the two extremes. This seems to ratify the conventional wisdom that speculative attacks appear suddenly and are short-lived events. From figures A.1.b-A.14.b, we see that the likelihood of switching to a speculative attack increases prior to attacks.

Tables A.1-A.7 in the appendix compare, for each country, the speculative attacks episodes identified by the exchange rate switching model, with the crises identified by the VAR switching model, and the attacks captured by Eichengreen et al.'s index of speculative pressure.[27] In the case of the exchange rate and the VAR switching models, we assume the process switched to a speculative attack state when the predicted probability of a speculative attack is greater than 0.5.[28] So a "Yes" for the exchange rate switching model and the VAR switching model signifies

[26] This is the so-called "smoothed" probability of a given regime.
[27] For both the VAR and the exchange rate switching models, we refer to the time-varying transition probabilities versions of these models.
[28] Since the estimated probability takes values close to zero or one, the classification of observations does not change significantly if we choose 0.6, 0.7, or 0.8 as a threshold.

that the probability of an attack predicted by each of these models is larger than 0.5. A "Yes" under the ERW column marks those episodes identified by Eichengreen et al.'s index of speculative pressure. Finally, the last column in these tables shows the dates when realignments of each ERM currency took place.

A number of well-established speculative attack episodes appear in the tables. The September 1992 ERM crisis and the speculative pressure that resulted in the widening of the ERM band in August 1993 show up for almost every country. Other dates which appear as episodes of speculative attacks, for at least half of the countries, correspond to the realignments of October 1981, March 1983, and January 1987. However, from the experiences of most countries, it is clear that speculative attacks need not always coincide with realignments.

We seek to address two questions regarding the speculative attacks episodes identified by the regime-switching methodology implemented in this paper. First, can this methodology capture those episodes identified by ERW's index of speculative pressure? Second, what other episodes does this methodology pick up and does it make sense to label them speculative attack episodes?

Table 4 below attempts to answer the first question posed above. This table summarizes the findings from tables A.1-A.7 in the appendix. For each country, table 4 shows the percentage of episodes identified by ERW that the VAR and exchange rate switching models identify. In summary, table 4 shows that, with the exception of Denmark, the VAR switching model can perfectly capture the episodes identified by ERW's index. On the other hand, the exchange rate switching model can only fully predict those episodes identified by ERW for the cases of Italy, Spain, and the UK. Both the VAR model and the ERW index incorporate the behavior of exchange rates, reserves, and interest rate differentials, while the exchange rate switching model only captures attacks that resulted in depreciations of the exchange rate. Most speculative attacks against Italy, Spain, and the UK resulted in depreciations of the exchange rate. Consequently, it is not surprising that for these countries the exchange rate switching model can identify all the attacks identified by ERW.

Table 4 enables us to verify that the VAR switching model can almost perfectly capture those episodes identified by the speculative pressure index methodology used by ERW. The next question is what else does the VAR switching methodology capture? Do these results make sense? In order to answer these questions, the first column in table 5 lists the number of episodes captured by the VAR switching model that are not captured by ERW's index of speculative pressure. The second column in that table reports the number of episodes listed in the first column for which we could find evidence of speculative pressure, on the relevant currencies, in the month in questions, in the financial press, or in IMF publications. Tables A.8 through A.14 in the appendix contain a list of all episodes identified by the VAR switching model followed by a description of events surrounding them. The main purpose of Table 5 and tables A.8-A.14 is to show that indeed most of the episodes the VAR switching model identifies can be corresponded with accounts of speculative pressure in the press or in the IMF's reports.

Table 5 shows that out of 25 attacks not identified by ERW, but captured by the VAR switching model, there are only 4 cases for which we cannot find evidence of speculative pressure in the news reports searched. Thus, the VAR regime-switching model can identify most of ERW's attacks plus others for which we find evidence in the news.

[Table 4 and 5 here]

8- Conclusions

This paper implemented a regime-switching approach with time-varying transition probabilities to study speculative attacks against EMS currencies. We estimated two switching models: an exchange rate and a VAR switching model. In the exchange rate switching model, speculative attacks are associated with large depreciations of the exchange rate. In the VAR switching model, speculative attacks may manifest themselves as depreciations of the exchange rate, large reserves losses, and/or significant increases in interest rate differentials.

The switching models allow the data to determine the state in which the economy resides at each point in time. Thus, these models avoid the arbitrary classification of observations that result from using indices of speculative pressure. Also, the estimation of the switching models enable us to study the factors affecting the likelihood that a country will shift from a state of tranquility to a speculative attack. Finally, contrary to other studies that neglect the role of expectations in causing speculative attacks, this paper incorporated them explicitly.

A number of conclusions follow from the results obtained in this paper. In the first place, the switching models with time-varying transition probabilities capture most of the conventional episodes of speculative attacks. Secondly, speculative attacks do not always coincide with currency realignments. Finally, both economic fundamentals and expectations determine the likelihood of switching from a period of tranquility to a speculative attack. In particular, in both switching models, the budget deficit appears to be the most important factor driving the probability of switching to a speculative regime.

There are a number of potential extensions to this paper. Two are particularly relevant. Given the importance of anticipating and wherever possible avoiding crises, a useful extension of this paper would be to conduct forecasting exercises to determine whether the switching framework proposed here can accurately forecast crises out of sample. Finally, given that currency crises tend to occur at the same time in more than one country, it would be interesting to adapt the regime-switching framework to explore the role of contagion in explaining crises.

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Table 1 - Exchange Rate Switching Model Estimates, 1979-1993

Variables	Model (1.1)		Model (1.2)		Model (1.3)*	
Autoregressive Parameters	**Coeff.**	**(T-stat.)**	**Coeff.**	**(T-stat.)**	**Coeff.**	**(T-stat.)**
Tranquil State (TS)						
$\alpha 00$– Constant	0.024	(1.84)	0.024	(1.85)	0.023	(1.77)
$\alpha 01$– Δe_{t-1}	0.148	(7.65)	0.148	(7.92)	0.15	(8.94)
$\alpha 02$– Δe_{t-2}	-0.013	(-0.84)	-0.012	(-0.74)	-0.013	(-0.83)
$\alpha 03$– Δe_{t-3}	0.034	(2.21)	0.033	(2.01)	0.035	(2.08)
$\alpha 04$– Δe_{t-4}	-0.001	(-0.04)	0.002	(0.12)	0.003	(0.16)
$\sigma 0$	0.108	(18.34)	0.099	(18.5)	0.097	(18.51)
Speculative State (SS)						
$\alpha 10$– Constant	1.357	(4.42)	1.197	(4.43)	1.173	(4.03)
$\alpha 11$– Δe_{t-1}	0.068	(0.91)	0.10	(1.38)	0.128	(1.59)
$\alpha 12$– Δe_{t-2}	-0.187	(-0.76)	-0.194	(-0.93)	-0.177	(-0.83)
$\alpha 13$– Δe_{t-3}	0.291	(1.66)	0.266	(1.88)	0.283	(1.95)
$\alpha 14$– Δe_{t-4}	-0.301	(-2.72)	-0.292	(-2.71)	-0.298	(-2.69)
$\sigma 1$	3.679	(8.89)	3.459	(8.25)	3.474	(7.05)
Transition Probabilities Parameters						
Tranquil State (TS)						
$\beta 00$– Constant	2.548	(11.98)	6.261	(2.81)	12.715	(2.85)
$\beta 01$– Domestic Credit Growth	-		0.065	(0.7)	0.133	(1.25)
$\beta 02$– Trade Balance	-		-0.886	(-1.62)	1.361	(0.61)
$\beta 03$– Real Exchange Rate	-		-0.03	(-1.41)	-0.045	(-1.35)
$\beta 04$– Interest Rate Differentials	-		-0.1	(-1.99)	-0.161	(-2.25)
$\beta 05$– Unemployment Rate	-		0.069	(0.94)	-0.097	(-0.58)
$\beta 06$– Government Surplus	-		0.11	(2.82)	0.339	(2.86)
Speculative State (SS)						
$\beta 10$– Constant	0.211	(0.76)	5.243	(1.48)	2.399	(0.21)
$\beta 11$– Domestic Credit Growth	-		-0.149	(-0.95)	0.026	(0.14)
$\beta 12$– Trade Balance	-		0.96	(0.79)	-1.835	(-0.67)
$\beta 13$– Real Exchange Rate	-		-0.053	(-1.52)	-0.01	(-0.19)
$\beta 14$– Interest Rate Differential	-		-0.061	(-0.52)	-0.126	(-0.65)
$\beta 15$– Unemployment Rate	-		0.203	(1.56)	-0.378	(-1.03)
$\beta 16$– Government Surplus	-		0.094	(1.31)	0.192	(0.79)

* Note model (1.3) was estimated including country dummies. We do not include these parameters since none of them is individually statistically significant.

Table 2 - VAR Switching Model Estimates, 1979-1993

Variables	Model (2.1)		Model (2.2)		Model (2.3)*	
VAR Parameters	**Coeff.**	**(T-Stat.)**	**Coeff.**	**(T-Stat.)**	**Coeff.**	**(T-Stat.)**
Exchange rate equation						
Tranquil State						
$c0^{*\Delta et}$ - Constant	0.058	(3.67)	0.054	(3.42)	0.055	(3.52)
$\alpha *^{\Delta et}$ - Δe_{t-1}	0.046	(2.65)	0.06	(3.28)	0.051	(2.65)
$\delta *^{\Delta et}$ - Δr_{t-1}	0.0004	(0.21)	0.001	(0.48)	0.001	(0.32)
$\gamma^{*\Delta et}$ – Δid_{t-1}	0.133	(12.39)	0.135	(12.19)	0.132	(10.86)
Speculative State						
$c0^{*\Delta et}$ - Constant	0.774	(4.16)	0.789	(4.19)	0.79	(3.92)
$\alpha *^{\Delta et}$ - Δe_{t-1}	0.254	(3.64)	0.218	(3.08)	0.214	(2.90)
$\delta *^{\Delta et}$ - Δr_{t-1}	-0.008	(-0.85)	-0.009	(-1.01)	-0.009	(-0.89)
$\gamma^{*\Delta et}$ – Δid_{t-1}	0.044	(1.35)	0.044	(1.37)	0.044	(1.29)
Reserves Equation						
Tranquil State						
$c0^{*\Delta rt}$ - Constant	1.095	(4.2)	1.092	(4.18)	1.133	(4.29)
$\alpha 00^{*\Delta rt}$ – Δe_t	-3.108	(-4.51)	-2.98	(-4.32)	-3.087	(-4.49)
$\alpha 01^{*\Delta rt}$ – Δe_{t-1}	-0.737	(-2.17)	-0.647	(-1.82)	-0.72	(-1.97)
$\delta *^{\Delta rt}$ – Δr_{t-1}	0.035	(1.15)	0.037	(1.22)	0.033	(1.089)
$\gamma^{*\Delta rt}$ – Δid_{t-1}	-1.03	(-3.16)	-1.054	(-3.17)	-1.058	(-2.98)
Speculative State						
$c0^{*\Delta rt}$ - Constant	1.417	(0.8)	1.447	(0.8)	1.26	(0.68)
$\alpha 00^{*\Delta rt}$ – Δe_t	-1.374	(-1.72)	-1.374	(-1.65)	-1.41	(-1.52)
$\alpha 01^{*\Delta rt}$ – Δe_{t-1}	-0.089	(-0.06)	-0.153	(-0.103)	-0.157	(-0.1)
$\delta *^{\Delta rt}$ – Δr_{t-1}	-0.301	(-3.79)	-0.296	(-3.67)	-0.289	(-3.51)
$\gamma^{*\Delta rt}$ – Δid_{t-1}	0.347	(0.87)	0.358	(0.89)	0.344	(0.86)
Interest rate differential Equation						
Tranquil State						
$c0^{*\Delta idt}$ - Constant	-0.064	(-3.38)	-0.061	(-3.26)	-0.062	(-3.22)
$\alpha 00^{*\Delta idt}$ - Δe_t	0.181	(3.69)	0.181	(3.65)	0.183	(3.64)
$\alpha 01^{*\Delta idt}$ - Δe_{t-1}	-0.008	(-2.71)	-0.007	(-2.56)	-0.007	(-2.49)
$\delta 00^{*\Delta idt}$ - Δr_t	0.011	(0.42)	0.015	(0.53)	0.027	(0.93)
$\delta 01^{*\Delta idt}$ – Δrt-1	-0.008	(-4.39)	-0.007	(-3.99)	-0.008	(-4.08)
$\gamma *^{\Delta idt}$ – Δi_{t-1}	0.078	(4.13)	0.078	(4.04)	0.084	(3.77)
Speculative State						
$c0^{*\Delta idt}$ - Constant	0.48	(1.38)	0.456	(1.28)	0.467	(1.31)
$\alpha 00^{*\Delta idt}$ - Δe_t	-0.216	(-0.9)	-0.207	(-0.85)	-0.203	(-0.83)
$\alpha 01^{*\Delta idt}$ - Δe_{t-1}	-0.0188	(-1.53)	-0.018	(-1.48)	-0.018	(-1.42)
$\delta 00^{*\Delta idt}$ - Δr_t	0.169	(0.49)	0.143	(0.41)	0.119	(0.38)
$\delta 01^{*\Delta idt}$ – Δr_{t-1}	-0.029	(-1.54)	-0.031	(-1.58)	-0.031	(-1.61)
$\gamma *^{\Delta idt}$ – Δi_{t-1}	-0.769	(-12.41)	-0.768	(-11.88)	-0.763	(-10.78)
Transition Probability Param.						
Tranquil State						
β00 – Constant	2.276	(14.22)	4.526	(2.75)	5.266	(2.19)
β01 – Domestic Credit	-		0.011	(0.14)	0.017	(0.19)
β02 – Trade Balance	-		0.556	(1.13)	-0.864	(-0.53)
β03 – Real Exchange Rate	-		-0.017	(-1.13)	-0.029	(-1.4)
β04 – Interest Rate Differential	-		-0.087	(-1.27)	0.005	(0.06)
β05 – Unemployment Rate	-		0.065	(1.18)	0.171	(1.66)
β06 – Government Surplus	-		0.072	(1.55)	0.254	(2.95)
Speculative State						
β10 – Constant	0.54 1	(2.93)	1.521	(1.04)	-6.632	(-1.83)
β11 – Domestic Credit	-		-0.044	(-0.55)	-0.073	(-0.86)
β12 – Trade Balance	-		-0.367	(-0.61)	-3.12	(-1.57)
β13 – Real Exchange Rate	-		-0.01	(-0.73)	0.039	(1.45)
β14 – Interest Rate Differential	-		0.008	(0.11)	-0.011	(-0.12)
β15 – Unemployment Rate	-		0.119	(1.54)	0.13	(0.9)
β16 – Government Surplus	-		0.082	(1.56)	0.079	(0.79)

For computational convenience, the exchange rate, reserves, and interest differential equations correspond to the Choleski transformed version of the model. * Model (2.3) was estimated including country dummies.

Table 3 - VAR Switching Model Estimates, 1988-1993

Variables	Model (3.1)*		Model (3.2)**	
Transition Probabilities Param.	**Coeff.**	**(T-Stat.)**	**Coeff.**	**(T-Stat.)**
Tranquil State (TS)				
β00– Constant	-58.979	(-0.39)	-28.76	(-0.55)
β01– Domestic Credit Growth	0.016	(0.06)	0.019	(0.07)
β02– Trade Balance	-1.277	(-0.08)	-1.065	(-0.07)
β03– Real Exchange Rate	0.569	(0.38)	0.27	(0.56)
β04– Expectations Proxy	-0.257	(-0.67)	-0.033	(-0.34)
β05– Unemployment Rate	1.581	(0.36)	1.359	(0.39)
β06– Government Surplus	0.797	(0.3)	0.9	(0.24)
Speculative State (SS)				
β10– Constant	-30.776	(-1.18)	-27.911	(-1.29)
β11– Domestic Credit Growth	0.106	(0.19)	0.113	(0.21)
β12– Trade Balance	0.804	(0.22)	0.773	(0.33)
β13– Real Exchange Rate	0.337	(1.25)	0.309	(1.41)
β14– Expectations Proxy	0.06	(0.06)	-0.014	(-0.95)
β15– Unemployment Rate	0.469	(0.85)	0.616	(1.65)
β16– Government Surplus	0.002	(0.01)	0.067	(0.27)

* Note model (3.1) includes the interest rate differential as a proxy for expectations.
** Note model (3.2) includes expected exchange rates (from survey data) as a proxy for expectations.

Table 4: ERW's Episodes Captured by the Exchange Rate and VAR Switching Models

Countries	% of ERW's episodes identified by the exchange rate switching model	% of ERW's episodes identified by the VAR switching model
Belgium	33%	100%
Denmark	50%	75%
France	75%	100%
Ireland	60%	100%
Italy	100%	100%
Spain	100%	100%
UK	100%	100%

Table 5: Number of Attacks not in ERW Identified by the VAR Switching Model

Countries	# of attacks not in ERW identified by the VAR switching model	# of attacks not in ERW identified by the VAR model for which there is evidence in the news
Belgium	9	9
Denmark	3	3
France	2	2
Ireland	0	0
Italy	8	6
Spain	2	1
UK	1	0

Appendix Figures and Tables

Figure A.1.a*

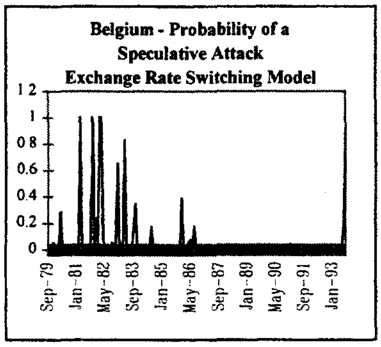


Figure A.1.b**

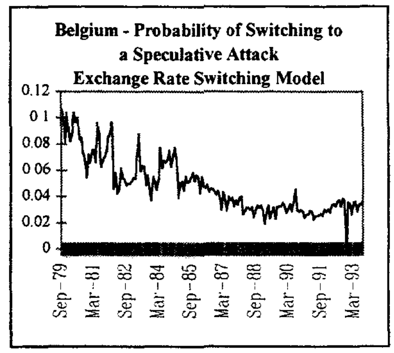
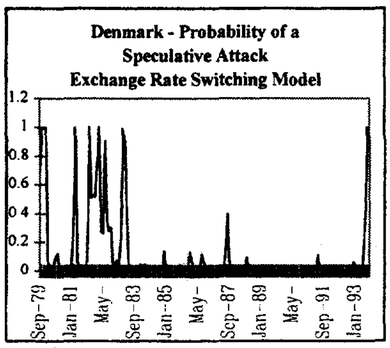


Figure A.2.a*



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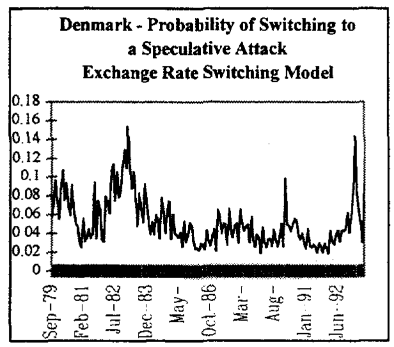


Figure A.3.a*

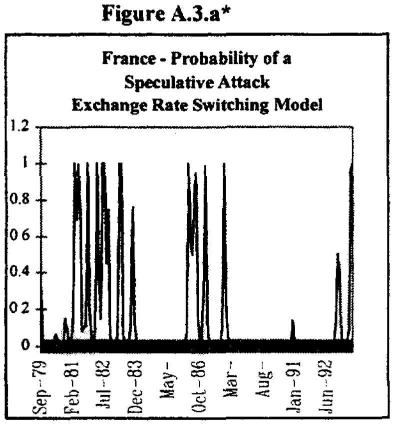
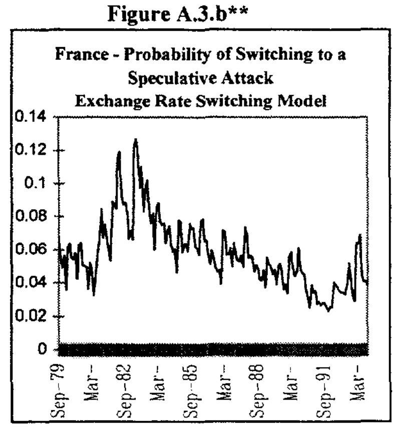


Figure A.3.b**



*Figures display the estimated probability of a speculative attack according to the exchange rate switching model.

**Figures display the estimated probability of switching from a tranquil period to a speculative attack regime according to the exchange rate switching model.

Figure A.4.a*

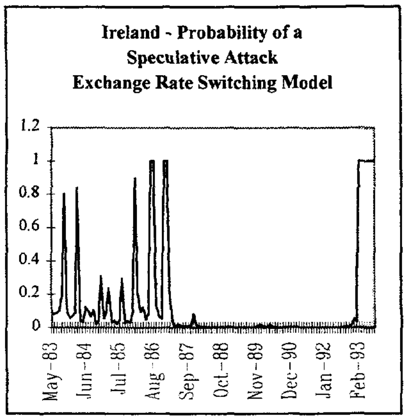


Figure A.4.b**

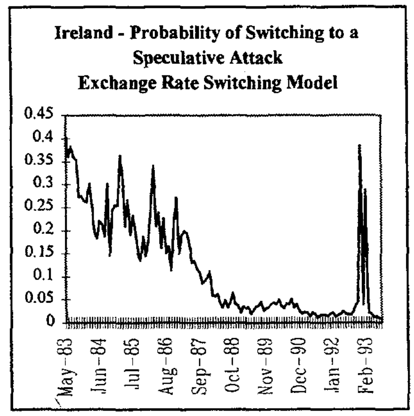


Figure A.5.a*

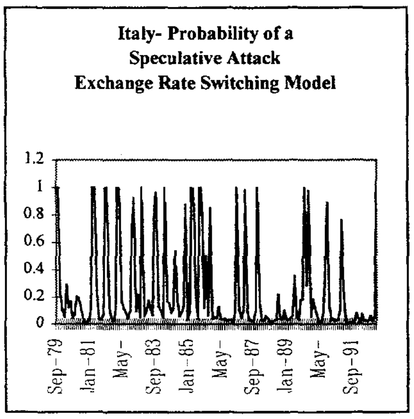


Figure A.5.b**

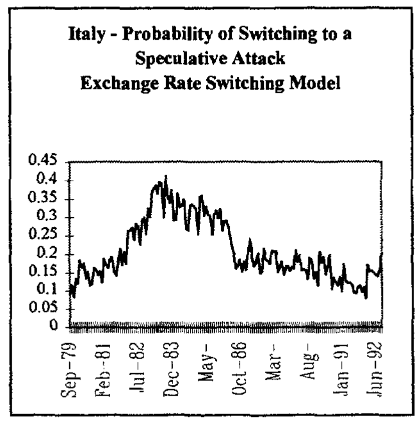
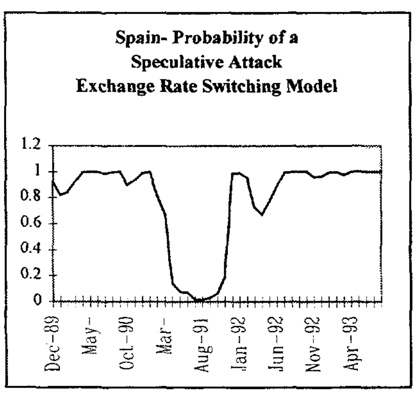


Figure A.6.a*



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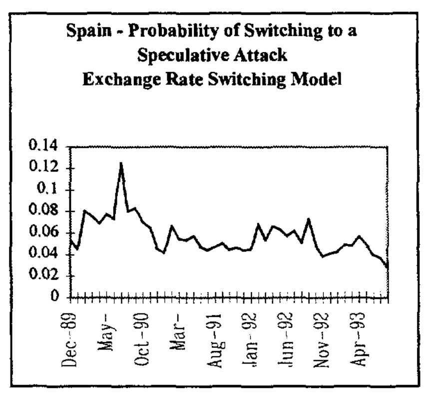
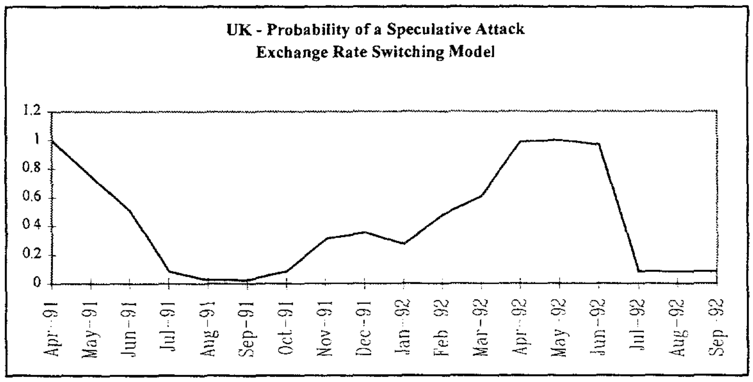


**Figures display the estimated probability of a speculative attack according to the exchange rate switching model.*

**Figures display the estimated probability of switching from a tranquil period to a speculative attack regime according to the exchange rate switching model.

Figure A.7.a*



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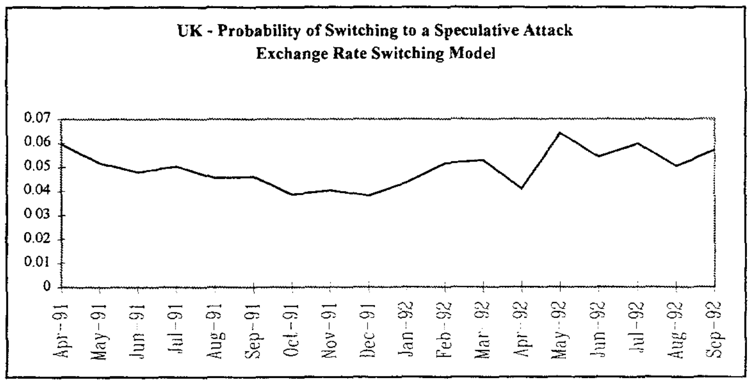


*Figure displays the estimated probability of a speculative attack according to the exchange rate switching model.

**Figure displays the estimated probability of switching from a tranquil period to a speculative attack regime according to the exchange rate switching model.

Figure A.8.a*

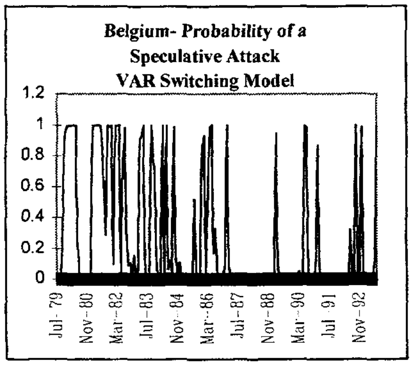


Figure A.8.b**

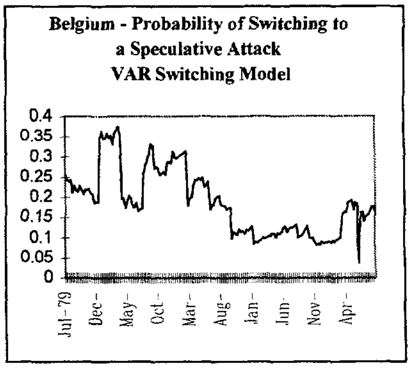


Figure A.9.a*

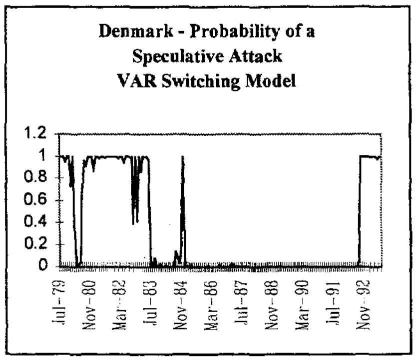


Figure A.9.b**

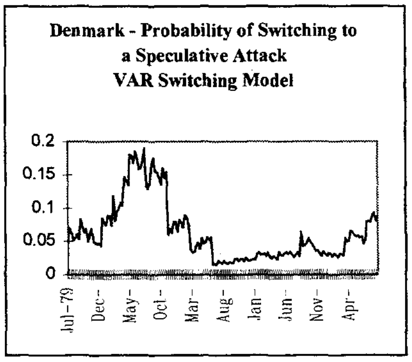


Figure A.10.a*

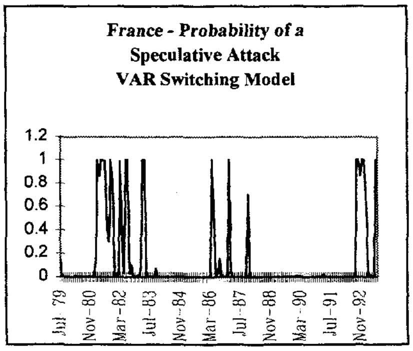
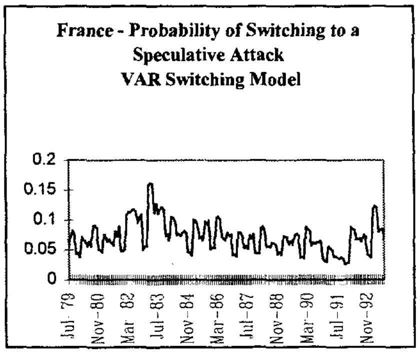


Figure A.10.b**



*Figures display the estimated probability of a speculative attack according to the VAR switching model.

**Figures display the estimated probability of switching from a tranquil period to a speculative attack regime according to the VAR switching model.

Figure A.11.a*

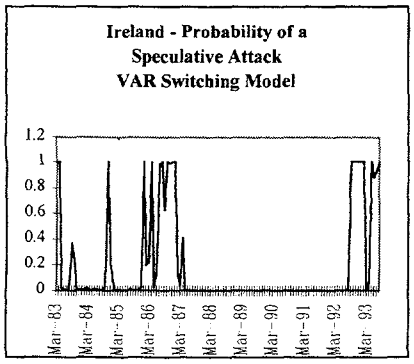


Figure A.11.b**

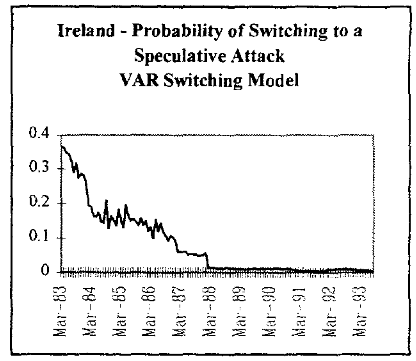


Figure A.12.a*

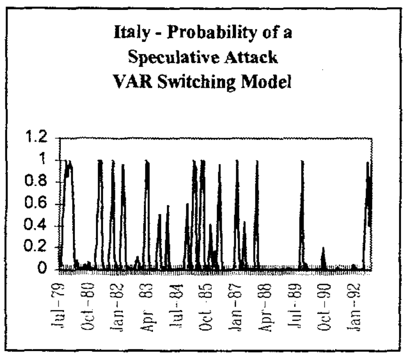


Figure A.12.b**

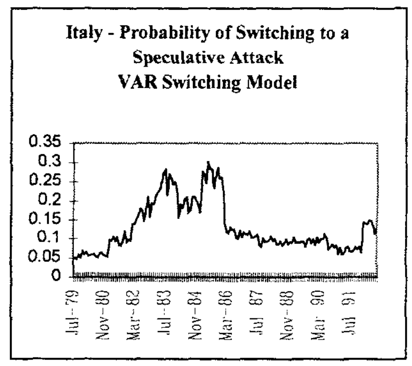


Figure A.13.a*

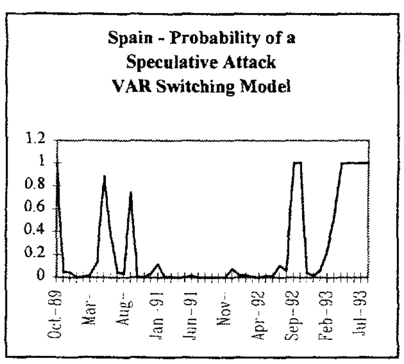
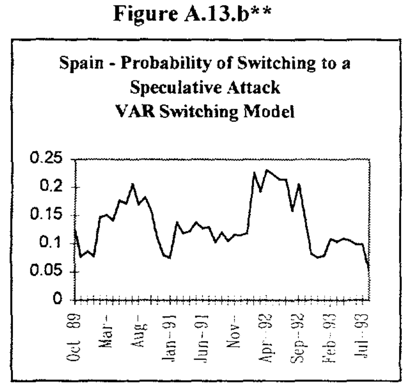


Figure A.13.b**



*Figures display the estimated probability of a speculative attack according to the VAR switching model.

**Figures display the estimated probability of switching from a tranquil period to a speculative attack regime according to the VAR switching model.

Figure A.14.a*

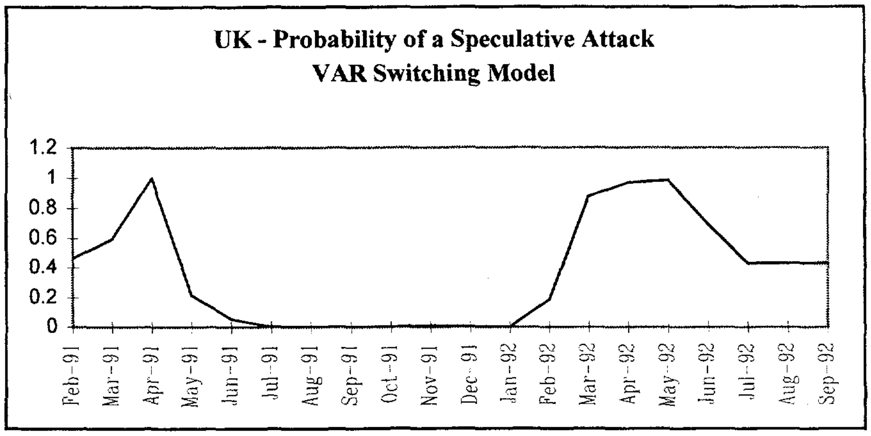


Figure A.14.b**

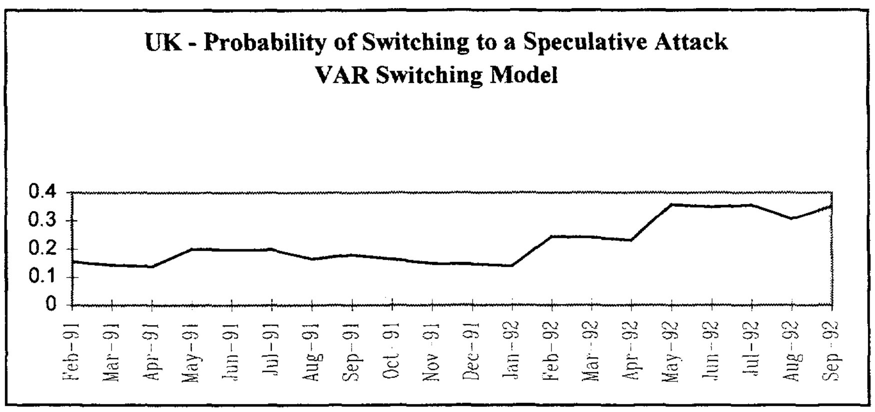


*Figure displays the estimated probability of a speculative attack according to the VAR switching model.

**Figure displays the estimated probability of switching from a tranquil period to a speculative attack regime according to the VAR switching model.

Table A.1.
Speculative Attack Episodes: Belgium

Dates of Speculative Attacks	*Attacks identified by the exchange rate switching model*	*Attacks identified by the VAR switching model*	*Attacks identified by ERW's index of speculative pressure*	*Realignment Dates*
Sept. 1979 - May 1980	No	Yes	No	1979:09:24
Feb. 1981 - Jul. 1981	Yes	Yes	No	-
Oct. 1981 - Apr. 1982	Yes	Yes	Yes	1981:10:05 & 1982:02:22
Jun. 1982 - Jul. 1982	No	Yes	Yes	1982:06:14
Mar. 1983 - May 1983	Yes	Yes	No	1983:03:21
Sept. 1983 - Nov. 1983	No	Yes	No	-
Mar. 1984 - Sept. 1984	No	Yes	No	-
Dec. 1985 - May 1986	No	Yes	No	1986:04:07
Jan. 1987	No	Yes	No	1987:01:12
Mar. 1989	No	Yes	No	-
Jun. 1990 - Jul. 1990	No	Yes	No	-
Sept. 1992 - Dec. 1992	No	Yes	Yes	-
Aug. 1993	Yes	Yes	N/A*	widening of ERM band

* Period not covered by this measure

Table A.2.
Speculative Attack Episodes: Denmark

Dates of Speculative Attacks	*Attacks identified by the exchange rate switching model*	*Attacks identified by the VAR switching model*	*Attacks identified by ERW's index of speculative pressure*	*Realignment Dates*
Jun. 1979 - Dec. 1979	Yes	Yes	Yes	1979:09:24 & 1979:11:30
Jul. 1980 - Mar. 1981	Yes	Yes	Yes	-
Oct. 1981 - Mar 1982	Yes	Yes	No	1981:10:05 & 1982:02:22
Jun. 1982 - Sep. 1982	Yes	Yes	No	1982:06:14
Mar. 1983 - May 1983	Yes	Yes	No	1983:03:21
Apr. 1986	No	No	No	1986:04:07
Jan. 1987	No	No	Yes	1987:01:12
Sept. 1992	No	Yes	Yes	-
Jul. 1993 - Aug. 1993	Yes	Yes	N/A*	widening of ERM band

* Period not covered by this measure

Table A.3.
Speculative Attack Episodes: France

Dates of Speculative Attacks	*Attacks identified by the exchange rate switching model*	*Attacks identified by the VAR switching model*	*Attacks identified by ERW's index of speculative pressure*	*Realignment Dates*
Sept. 1979	No	No	No	1979:09:24
Mar. 1981 - Nov. 1981	Yes	Yes	Yes	1981:10:05
Mar. 1982 - Sept. 1982	Yes	Yes	Yes	1982:06:14
Mar. 1983 - Apr. 1983	Yes	Yes	No	1983:03:21
Apr. 1986 - Aug. 1986	Yes	Yes	No	1986:04:07
Jan. 1987	Yes	Yes	Yes	1987:01:12
Nov. 1987	Yes	No	No	-
Sept. 1992 - Dec. 1992	No	Yes	Yes	-
Jul. 1993 - Aug. 1993	Yes	Yes	N/A*	widening of ERM band

* Period not covered by this measure

Table A.4.
Speculative Attack Episodes: Ireland

Dates of Speculative Attacks	*Attacks identified by the exchange rate switching model*	*Attacks identified by the VAR switching model*	*Attacks identified by ERW's index of speculative pressure*	*Realignment Dates*
Sept. 1979	N/A*	N/A*	No	1979:09:24
Oct. 1981	N/A*	N/A*	No	1981:10:05
Jun. 1982	N/A*	N/A*	Yes	1982:06:14
Mar. 1983 - Jun. 1983	No	Yes	Yes	1983:03:21
Jan. 1986 - Aug. 1986	Yes	Yes	Yes	1986:04:07 & 1986:08:04
Dec. 1986 - Feb. 1987	Yes	Yes	Yes	1987:01:12
Sept. 1992 - Jan. 1993	No	Yes	Yes	-
Feb. 1993 - May 1993	Yes	Yes	Yes	1993:02:01
Jul. 1993 - Aug. 1993	Yes	Yes	N/A*	widening of ERM band

* Period not covered by this measure

Table A.5.
Speculative Attack Episodes: Italy

Dates of Speculative Attacks	*Attacks identified by the exchange rate switching model*	*Attacks identified by the VAR switching model*	*Attacks identified by ERW's index of speculative pressure*	*Realignment Dates*
Sept. 1979 - Jan. 1980	Yes	Yes	No	1979:09:24
Mar. 1981 - Apr. 1981	Yes	Yes	No	1981:03:23
Sept. 1981 - Oct. 1981	Yes	Yes	Yes	1981:10:05
Mar. 1982 - Apr. 1982	Yes	Yes	Yes	-
Jun. 1982	No	No	No	1982:06:14
Oct. 1982 - Nov. 1982	Yes	No	No	-
Mar. 1983 - Apr. 1983	Yes	Yes	No	1983:03:21
Sept. 1983 - Oct. 1983	Yes	No	No	-
Feb. 1984	Yes	No	No	-
Dec. 1984	Yes	No	No	-
Mar. 1985 - Apr. 1985	Yes	Yes	No	-
Jul. 1985 - Aug. 1985	Yes	Yes	No	1985:07:22
Dec. 1985	Yes	No	No	-
Apr. 1986	No	Yes	No	1986:04:07
Jan. 1987 - May 1987	Yes	Yes	Yes	1987:01:12
Nov. 1987	Yes	Yes	No	-
Dec. 1989	Yes	Yes	No	1990:01:08
Sept. 1990	Yes	No	No	-
Jul. 1992 - Sept. 1992	Yes	Yes	Yes	Exit ERM 1992:09:17

Table A.6
Speculative Attack Episodes: Spain

Dates of Speculative Attacks	*Attacks identified by the exchange rate switching model*	*Attacks identified by the VAR switching model*	*Attacks identified by ERW's index of speculative pressure*	*Realignment Dates*
Oct. 1989 - Dec. 1989	Yes	Yes	No	-
Apr. 1990 - May 1990	Yes	Yes	No	-
Jul. 1990 - Mar. 1991	Yes	No	No	-
Dec. 1991 - May 1992	Yes	No	No	-
Sept. 1992 - Oct. 1992	Yes	Yes	Yes	1992:09:13 & 1992:11:22
Mar. 1993 - Aug. 1993	Yes	Yes	N/A*	1993:05:13

* Period not covered by this measure

Table A.7.
Speculative Attack Episodes: UK

Dates of Speculative Attacks	*Attacks identified by the exchange rate switching model*	*Attacks identified by the VAR switching model*	*Attacks identified by ERW's index of speculative pressure*	*Realignment Dates*
Mar. 1991 - Jun. 1991	Yes	Yes	No	-
Mar. 1992 - Sept. 1992	Yes	Yes	Yes	Exit ERM 1992:09:16

Table A.8 - Evidence of Speculative Pressure: Belgium

1979:09-1980:05

• A realignment of EMS currencies took place on September 24, 1979. The revaluation of the Deutsche mark (DM) implied a 2 percent devaluation of the Belgian franc against this currency. Source: IMF Annual Report on Exchange Arrangements and Restrictions (IMF AREAR), 1980.

1981:02-1981:07

• The Belgian franc breached its divergence threshold several times in February-March 1980 and again in February 1981 necessitating intervention and tighter monetary measures. Source: IMF AREAR, 1981.

1981:10-1982:03

• On October 5, the DM was revalued by 5.5 percent. This realignment implied a 5.5 percent devaluation of the Belgian franc vis-à-vis the DM. Subsequent to the realignment, the Belgian franc needed continued support. Pressure on the Belgian franc intensified in December. On February 22, 1982 a realignment of the grid took place. The adjustment resulted in a devaluation of the Belgian franc and the Danish krone by 8.5 percent and 3 percent, respectively, against other currencies. Source: IMF AEAR, 1982.

1982:06

• With effect from June 14, 1982, a general realignment took place. The revaluation of the DM implied an effective 4 percent devaluation of the Belgian franc against this currency. Source: IMF AEAR, 1982.

1983:03-1983:04

• The Bundesbank intervened to support the Belgian franc. Source: The Economist, March 12, 1983.

• The Belgian franc was devalued with respect to the DM, Netherlands guilder, and the Danish krone but revalued against the French franc, Italian lira, and Irish punt. The devaluation of the Belgian franc against the DM was of 4 percent. Source: IMF AEAR, 1984.

• The National Bank of Belgium reportedly spent up to 15 billion Belgian francs in support of the franc. With the franc on the floor of the EMS grid, the Belgian government announced a surprise 2.5 percent increase in interest rates to 14 percent. Source: Financial Times, March 22, 1983.

1983:09-1983:10

• The Belgian central bank raised its discount rate from 9 to 10 percent. The central bank spent 80 billion Belgian francs since August in support of the currency. Source: Financial Times, November 24, 1983.

1984:03-1984:09

• The National Bank of Belgium raised interest rates and intervened heavily in support of the Belgian franc, given that it fell to its floor vis-à-vis the DM. Source: The Economist, March 10, 1984.

1985:12-1986:07

• On April 5, 1986, the Financial Times reported that the Belgian franc and Italian lira could follow the French franc in a devaluation given the speculative pressure against these currencies. Source: Financial Times, April 5, 1986.

• With effect from April 7, a realignment of the ERM central rates took place. The realignment implied a 2 percent devaluation of the Belgian franc against the DM. Source: IMF AEAR, 1987.

1987:01

• Speculation forced France, Belgium, and Denmark to raise interest rates to defend their currencies and, also, seriously depleted these countries' reserves. Source: Financial Times, January 10, 1987.

• On January 12, 1987, the Belgian franc was devalued by only 1 percent against the DM in a general realignment. Source: IMF AEAR, 1988.

1989:03

• The National Bank of Belgium raised key interest rates hiking the discount rate by 0.5 points to 8.75 in response to speculative pressure against the franc. Source: Reuters News, April 21, 1989.

1990:06-1990:07

• Belgian foreign currency reserves fell 6.82 billion francs to 233.18 billion francs in the five days to July 20. Source: Reuters News, July 25, 1990.

1992:09-1992:12

• No evidence of a speculative attack. According to Reuters, the Belgian franc remained stable throughout this period. Rates were cut and the Belgian National bank intervened in favor of the lira and the punt.

1993:08

• Belgium tightened monetary conditions to resist speculative attacks against the Belgian franc pushing its central rate up to 7.5 percent from 6.7 percent. Source: Financial Times, July 23rd, 1993.

Table A.9 - Evidence of Speculative Pressure: Denmark

1979:06-1979:12

- A realignment of EMS currencies took place on September 24, 1979. The Danish krone was devalued by 5 percent. Subsequently, as part of a program to strengthen Denmark's external position, the bilateral intervention limits in that country were raised by 5 percent against the Danish krone, effective November 30, 1979. Between March 1979 and December 1979, the Danish krone reached its lower divergence thresholds on several occasions. Source: IMF AEAR, 1980.

1980:08-1981:03

- With effect, March 23, 1981, Italy devalued the lira by 6 percent against the other currencies participating in the EMS. No other exchange rate adjustment was made, but the system became subject to occasional strain and the Danish krone came under attack. Source: IMF AEAR, 1981.

1981:10

- On October 5, the Deutsche mark and the Netherlands guilder were revalued by 5.5 percent. This realignment implied an effective 5 percent devaluation of the krone against the DM. Source: IMF AEAR, 1982.

1982:02

- The Danish krone came under intense pressure in early 1982 with the result that on February 22, 1982 a realignment of the grid took place. The adjustment resulted in a 3 percent devaluation of the Danish krone against other currencies, respectively. Source: IMF AEAR, 1982.

1982:06

- Following renewed pressure within the EMS a new realignment was decided upon on June 12. This realignment implied a 4 percent devaluation of the krone against the DM. Source: IMF AEAR, 1982

1983:03

- The Danish krone reached its floor against the DM on March 9, 1983. Source: Financial Times, March 9, 1983.
- The Bundesbank intervened in support of the Danish krone. Source: The Economist, March 12, 1983.
- Pressures on exchange rates within the EMS reappeared. A general realignment took place that implied a 3 percent devaluation of the Danish krone with respect to the DM and the guilder. Source: IMF AEAR, 1984.

1986:04

- The Danish krone was devalued by 2 percent with respect to the DM and the guilder in a general realignment. Source: IMF AEAR, 1986.

1987:01

- Speculation forced France, Belgium, and Denmark to raise interest rates to defend their currencies and seriously depleted their reserves. Source: Financial Times, January 10, 1987.
- A realignment of the central rates with the EMS was implemented on January 12, resulting in an effective 3 percent devaluation of the krone vis-à-vis the DM. Source: IMF AEAR, 1988.

1992:09

- The Danish krone, French franc, and Irish punt fell to their floors in the ERM, prompting central bank intervention, as speculators moved on to new targets after pummeling the pound, lira, and peseta. Source: Financial Times, September 18, 1992.
- The Danish Central bank countered speculative pressure against the krone by tightening money market liquidity. Source: Reuters News, September 25, 1992.

1993:08

- The Danish krone was subject to intense speculative pressure similar to that suffered by the French franc with authorities forced to increase interest rates in its defense. Source: Financial Times, July 24, 1993.

Table A.10 - Evidence of Speculative Pressure: France

1981:03-1981:11

- The French franc came under pressure following the French presidential elections and the monetary authorities of some EMS members intervened heavily in May to keep the French franc within the agreed margins. The French franc and the Belgian franc came under pressure against the DM again in September. Finally on October 5, a realignment took place that entailed an overall depreciation of 8.1 percent of the franc against the DM and the Netherlands guilder. Source: IMF AEAR, 1982.
- France spent $1.3b defending the franc prior to the October realignment. Source: The Economist, October 10, 1981.

1982:03-1982:09

- Following renewed pressure within the EMS, especially against the French franc, a realignment was decided on June 14, 1982. This realignment implied an effective devaluation of the franc against the DM of almost 10 percent. Source: IMF AEAR, 1982-83.

1983:03

- A realignment of the parity grid took place March 21. The French franc was devalued against the DM by almost 8 percent. Source: IMF AEAR, 1984

1986:04

- A realignment took place that meant an effective 6 percent devaluation of the franc vis-à-vis the DM. Source: IMF AEAR, 1986.
- The devaluation of the French franc was the first major realignment of the EMS since 1983. Speculative pressure had been mounting since mid-March. Source: Financial Times, April 7, 1986.

1986:09-1987:01

- France raised rates by 1 percent after intense pressure on the franc. Source: Financial Times, December 9, 1986.
- Renewed pressure on the French franc forced the Bank of France to raise its seven-day repurchase rate by half a percentage to 8.25 percent. The franc fell to a rate against the DM close to its floor. Source: Financial Times, December 31, 1986.
- Speculation forced France, Belgium, and Denmark to raise interest rates to defend their currencies. Source: Financial Times, January 10, 1987.
- A realignment of the central rates within the EMS was implemented on January 12. This resulted in an appreciation of the DM, Netherlands guilder, Belgian franc, and Luxembourg franc. All other currencies remained unchanged. Source: IMF AEAR, 1987

1992:09-1992:12

- Germany and France forged a united front to defend the French franc from speculative attacks. France pushed its short-term rate sharply higher and both the German Bundesbank and the Bank of France intervened heavily in support of the franc. The Bank of France raised its five to ten day repurchase rate from 10.5 percent to 13 percent triggering a sharp rise in money market rates. Source: Financial Times, September 24, 1992.
- The speculation against the ERM in September was unprecedented. Bundesbank intervention in support of the lira, sterling, and French franc reached 92 billion DMs. Source: Financial Times, November 16, 1992.
- The French franc was again under pressure following the 6 percent devaluation of the Spanish peseta and Portuguese escudo on November 22. Source: Financial Times, December 12, 1992.

1993:07-1993:08

- Massive central bank intervention estimated at 15 billion DMs on the part of the Bundesbank alone failed to give the franc more than fleeting support in the ERM. The Bank of France pushed up its 24 hour lending rate to 10 percent from 7.75 percent. Source: Financial Times, July 24, 1993.

Table A.11 - Evidence of Speculative Pressure: Ireland

1983:03-1983:06
• A realignment of the parities took place on March 21. The punt was devalued by 8.53 percent against the DM. Source: IMF AEAR, 1984.
1986:01-1986:08
• In April 1986, a realignment resulted in a devaluation of the punt of 3 percent against the DM. In August 1986, the Irish punt was devalued again, this time by 8 percent. Source: IMF AEAR, 1987
1986:12-1987:01
• The Irish punt was effectively devalued by 3 percent against the DM.
1992:09-93:02
• The Danish krone, French franc, and Irish punt fell to their floors in the ERM, prompting central bank intervention, as speculators moved on to new targets after pummeling the pound, lira, and peseta. Source: Financial Times, September 18, 1992.
• The Irish punt was under intense selling pressure during September 1992. Source: Financial Times, September 24, 1992.
• The Irish punt was unaffected by the November realignment of the peseta and the escudo despite of speculation against this currency. Source: Financial Times, November 23, 1992.
• Ireland was forced to push interest rates to usurious levels in the hope of maintaining the exchange rate parities. Source: Financial Times, December 12, 1992.
• On January 30, 1993, the Irish punt was devalued by 10 percent. Source: IMF AEAR, 1994.
1993:07-08
• The punt plunged nearly 3.5 percent in just three days following the recent ERM band widening. Source: Reuters News, August 10, 1993.

Table A.12 - Evidence of Speculative Pressure: Italy

1979:09-1980:01

• On September 24, 1979 the lira was effectively devalued by 2 percent against the DM. Source: IMF AEAR, 1980.

1981:03

• The Italian lira came under pressure at the beginning of March. Effective March 23, the Italian lira was devalued by 6 percent against all other EMS currencies. Source: IMF AEAR, 1981.

1981:09-1981:10

• On October 5, the lira was effectively devalued by 8 percent against the DM. Source: IMF AEAR, 1982

1982:03

• Following the devaluation of the Belgian franc (8.5 percent) in February 1982, France and Italy came under attacks. With inflation in France and Italy running at twice the Belgian level speculative attacks shifted towards these most vulnerable members. Source: Financial Times, April 1, 1982.

1982:06

• In June 14, 1982, the lira was effectively devalued by 7 percent against the DM. Source: IMF AEAR, 1982.

1983:03

• Changes in the grid meant that the lira was devalued by 8 percent against the DM. Source: IMF AEAR, 1984.

1985:03-198:04

No evidence.

1985:07

• The central rates of the EMS were realigned. Changes involved a devaluation of 7.8 percent in the bilateral central rates of the Italian lira. Source: IMF AEAR, 1986

1986:04

• Italian lira and French franc were devalued against all other currencies.
The realignment implied an effective 3 percent devaluation of the lira. Source: IMF AEAR, 1987

87:11

No evidence.

1989:12

• The Bank of Italy sold 161 million marks at the fixed rate as the lira slid to its 15 month low against the mark. Source: Reuters news, December 15, 1989.

• The lira was devalued by 3.8 percent against its EMS central rates on January 10, 1990. Source: Financial Times, January 10, 1990.

1992:09

• Italy forced up interest rates by 1.75 percent points, the biggest increase in 11 years and drew on international bank credits in an attempt to protect the lira. Source: Financial Times, September 6, 1992.

• On September 13, the central rate of the lira against other currencies was devalued by 7 percent.

• On September 17, the lira was withdrawn from the ERM. Source: IMF AEAR, 1993.

Table A.13 - Evidence of Speculative Pressure: Spain

1989:10-1989:12
• October 24, Spain fights pressure against the peseta. Source: Financial Times, October 24, 1989.
• October 26, The Bank of Spain intervened to support the peseta selling 290 million marks at a fixing rate of 63.8 pesetas. It was the central bank fifth intervention in a week. Source: Reuters news October 26, 1989.
• Bank of Spain sold 96.65 million dollars to brake the Spanish currency decline against the mark. Source: Reuters news October 20, 1989.
1990:04-1990:06
No evidence
1992:09-1992:11
• On September 17, the central rate of the peseta against the central rates of the currencies participating in the ERM of the EMS was devalued by 4.8 percent. Source: IMF AEAR, 1993.
• On November 22, the central rate of the peseta against the central rates of the currencies participating in the ERM of the EMS was devalued by 6 percent. Source: IMF AEAR, 1993.
1993:04-1993:08
• The Bank of Spain raised unofficial intervention rates and intervened strongly on the market to defend the peseta's central parity rate. The Madrid authorities took action by raising intervention rates from 13.35 percent to 14 percent and put aside 45 billion dollars for the peseta's defense. Source: Financial Times, April 23, 1993.
• On May 13, the central rate of the peseta against the central rates of the currencies participating in the ERM of the EMS was devalued by 8 percent. Source: IMF AEAR, 1994.

Table A.14 - Evidence of Speculative Pressure: UK

1991:04-1991:06
No evidence
1992:03-1992:09
• The British government borrowed 7.27 billion pounds of DM and other currencies and sold these for sterling to support the currency. Source: Financial Times, September 4, 1992.
• On September 16, the UK suspended intervention obligations with respect to the exchange and intervention mechanism of the EMS. Source: IMF AEAR, 1993.

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